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THE UNIFIED TRI-SERVICE COGNITIVE PERFORMANCE ASSESSMENT BATTERY (UTC-PAB):

II: HARDWARE/SOFTWARE DESIGN AND SPECIFICATIONS

ADA 219 600

by D.L. Reeves, D.R. Thorne, S.L. Winter, F.W. Hegge and others

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This report was submitted jointly by personnel from the Walter Reed Army Institute of Research, Washington, DC, and the Naval Aerospace Medical Research Laboratory, Naval Air Station, Pensacola, Florida. Publication costs were supported by the U.S. Army Research and Development Command, Fort Detrick, Maryland. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of the Army, Department of Defense, nor the U.S. Government.

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This report has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NAMRL-WRAIR	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION NAVAEROMEDRSCHLAB Code 21 WRAIR-Department of Neuropsychiatry 6b. OFFICE SYMBOL (*If applicable*)	7a. NAME OF MONITORING ORGANIZATION WRAIR-SGRD-UWI/LTC Sessions
6c. ADDRESS (*City, State, and ZIP Code*) NAS, Pensacola, FL 32508-5700 CDR, WRAIR, ATTN: UWI/LTC Sessions Washington, DC 20307-5100	7b. ADDRESS (*City, State, and ZIP Code*) Commander, WRAIR SGRD-UWI/LTC Sessions Washington, DC 20307-5100
8a. NAME OF FUNDING/SPONSORING ORGANIZATION USAMRDC 8b. OFFICE SYMBOL (*If applicable*) USAMRDC SGRD-PLE	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (*City, State, and ZIP Code*) Fort Detrick Fredrick, MD 21701	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 63764A PROJECT NO. 3M463764 TASK NO. D995 AB WORK UNIT ACCESSION NO. 072WW19

11. TITLE (*Include Security Classification*)
(U) The Unified Tri-service Cognitive Performance Assessment Battery (UTC-PAB). II. Hardware/Software Design and Specifications

12. PERSONAL AUTHOR(S)
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13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (*Year, Month, Day*)	15. PAGE COUNT
Final	FROM _____ TO _____	1988 December	16

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUB-GROUP	Psychology; Human Performance; Computer Testing

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)

The Tri-service Joint Working Group on Drug Dependent Degradation of Military Performance (JWGD3 MILPERF) has been given responsibility for developing and implementing a program to screen medical chemical defense pretreatment and treatment drugs. The screening program is based on a multiple level assessment of performance. This report provides a description of the hardware and software environment that is being developed in support of the Level II Unified Tri-service Cognitive Performance Assessment Battery (UTC-PAB). The objective of the present effort is to establish a performance assessment system (PAS) that will promote standardization and interoperability, and provide a vehicle for establishing an inter-laboratory communications and data network among the participating JWGD3 MILPERF military and civilian contractor laboratories.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL J.A. BRADY, CAPT MSC USN, Commanding Officer	22b. TELEPHONE (*Include Area Code*) (904) 452-3286	22c. OFFICE SYMBOL 00

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

★U.S. Government Printing Office: 1986—607-047

SUMMARY PAGE

THE PROBLEM

Behavioral science has traditionally implemented a wide range of metrics that have employed an equally wide range of hardware systems for collecting data. The outcome has been the development of a body of literature that describes results that differ from seemingly similar experiments. The apparently conflicting results can be attributed largely to a lack of standardization of laboratory equipment and tests. This was deemed unacceptable by a network of Tri-service laboratories, and a solution is at hand.

FINDINGS

The Joint Working Group on Drug Dependent Degradation of Military Performance (JWGD3 MILPERF) created a performance assessment system (PAS) that utilizes standardized hardware and software with a microcomputer as the central component. The system is rugged, transportable, and versatile and is composed of commercially available products. Other design considerations included low acquisition and maintenance costs, high reliability, turn-key testing, ready modification, and automatic scoring capabilities. The PAS hardware has undergone 2 years of testing, and final modifications are now completed.

RECOMMENDATIONS

The PAS described in this report has become an established and reliable instrument. We recommend it for laboratories concerned with assessment of sensory, perceptual, and cognitive processing in humans.

Acknowledgments

The authors would like to extend a special thanks to Rachel Gadolin, Kathleen Mayer, Kathryn Winter, and Cynthia Kresslein for technical and administrative assistance during the production of this report.

INTRODUCTION

The Joint Working Group on Drug Dependent Degradation of Military Performance (JWGD3 MILPERF), a tri-service group of scientists, was given responsibility for developing and implementing a program to screen chemical defense pretreatment and treatment drugs. The goal of this program was to evaluate the impact of drugs on military performance. The product will be information that supports the development of drug-use guidelines that minimize adverse influences on critical military performance.

The screening program is based on a multiple level assessment of performance. This report describes the hardware and software environment that is being developed in support of the Level II Unified Tri-service Cognitive Performance Assessment Battery (UTC-PAB). The objective of the present effort is to establish a standardized performance assessment system (PAS) that will promote interoperability, and provide a vehicle for establishing an interlaboratory communications network and valid data exchange among the participating JWGD3 military and civilian contractor laboratories.

Recently, cognitive performance assessment relied on either paper-and-pencil tests, specialized apparatus, or minicomputers and mainframe computers. These methods entailed high overhead for administration and scoring, lack of flexibility, substantial acquisition and maintenance costs, lack of portability, and in time-shared systems, limitations on response.

To avert similar system-related inadequacies, the PAS design has emphasized standardization of hardware and software. The hardware system is based on microcomputers that are rugged, transportable, and versatile. Additional requirements were low acquisition and maintenance costs, high reliability, and upward compatibility with new and future systems.

Following a systematic evaluation of early developmental systems (e.g., Apple IIc/e and Commodore 64), the IBM PC and its compatible competitors was selected as the JWGD3 MILPERF microcomputer standard. In addition, hardware standards were selected for color graphics, display monitor specifications, response apparatus, and a local area network (LAN) system (Fig. 1). These standards were originally published in JWGD3 MILPERF Report No. 85-2. This report constitutes an upgrade and expansion of the prior report, based on hardware and technology currently available.

The PAS will include telephone communications with secure electronic mail and file transfer to facilitate resource sharing between laboratories. Finally, the design incorporates a "stand-alone" option. Each workstation can be disconnected from the network and operated independently at remote locations. Phone transmission of data to the network is also supported.

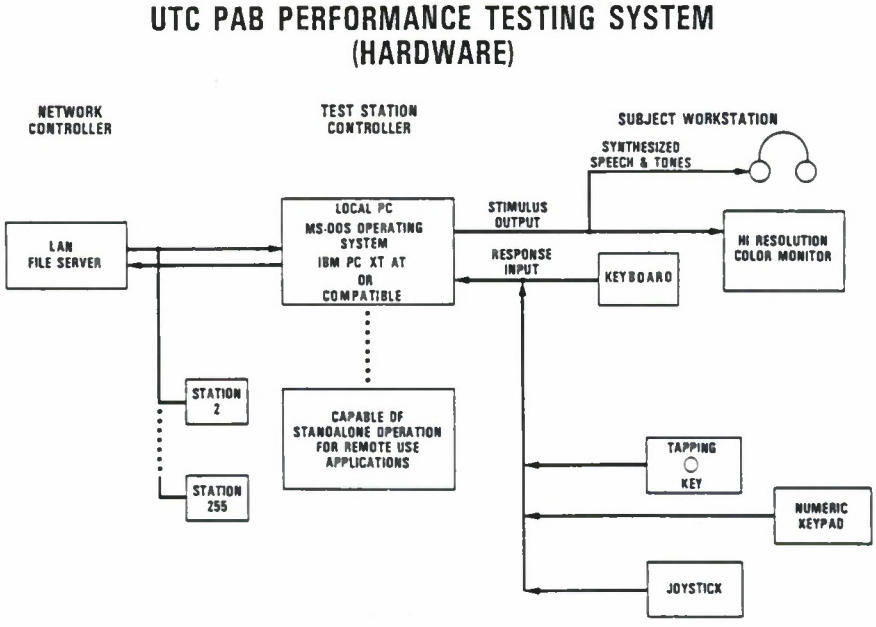

Figure 1. Schematic representation of the UTC-PAB hardware system depicting an individual laboratory system.

THE UTC-PAB HARDWARE SYSTEM

This section includes a listing of specifications of required components for the UTC-PAB hardware environment. Retail sources (where appropriate) for this equipment are listed at the end of this section.

MICROPROCESSOR

The UTC-PAB test system is designed to run on IBM-PC compatible microcomputers (Fig. 2) meeting the following minimal specifications:

1. Central processing unit (CPU). A 16-bit 80286 processor with a clock speed of 8.0 MHz.

2. Math coprocessor. 80287 math coprocessor.

3. Disk storage. Two soft-sector, double-sided, double-density, 48 tracks-per-inch, 360 kilobyte (KB), 5.25-in floppy disk drives and one 20 megabyte (MB) hard disk drive.[1]

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[1] Although not absolutely essential, a 20MB hard disk is highly recommended. The UTC-PAB code is extensive, and loading and execution times are noticeably slower when run on "floppy drive only" systems.

Figure 2. The UTC-PAB single-subject system. The core hardware system is illustrated. Specifically shown is the IBM-AT compatible Zenith Z-248, with a high resolution graphics monitor and standardized subject workstation.

4. Random Access Memory (RAM). 640KB RAM memory.

5. Buss. Must be IBM-PC compatible, with four unused slots minimum.

6. Input/Output. Two RS-232C serial ports and one parallel port. The serial ports must be configurable as DTE ports. The parallel port must be a standard Centronics-type port.

7. Operating System. MS-DOS (or equivalent) operating system version 2.0 or above.

Two Air Force/Navy contracts were available for the purchase of desktop microcomputers. The Zenith Z-248 desktop microcomputer was available from contract F19630-86-D-0002, which expired in February of 1989. A TEMPEST version is available from contract F19630-84-D-0009, which expires in October of 1989. A TEMPEST microcomputer is recommended if radio-frequency (RF) shielding is necessary for collecting data in electronically "noisy" environments or for security concerns. Equipment equivalent to the non-TEMPEST Z-248 will be available on a follow-on contract, expected to be in place in October of 1989, and is currently available from a variety of vendors, including Zenith Data Systems.

The following items meet the minimal specifications required for this system:

1. Basic System. IBM-AT compatible microcomputer with 80286 microprocessor, 8 MHz clock speed, 512KB RAM memory, two 360KB floppy disk drives, six open IBM-PC compatible buss slots, internal clock/calendar, two RS-232C serial ports, and two Centronics-type parallel ports.

2. Math coprocessor. 80287 math coprocessor.

3. Hard disk storage. 20MB hard disk drive with interface cables.

4. Memory expansion. 640KB RAM memory expansion board.

5. Surge suppressor.

Although older IBM-PC and XT-compatible systems based on a 4.77-MHz 8088 processor with an 8087 math coprocessor will run the UTC-PAB software, the 8-MHz 80286 configuration is recommended.

VIDEO CONTROLLER

An extended graphics adapter (EGA) color graphics board with 128K onboard memory and 640 x 350 pixel resolution is the minimal requirement. The standard video board (Z-449) provided with the Zenith Z-248 fulfills these requirements.

VIDEO DISPLAY

Video display specifications are a 12-14 in (diagonal measurement) high-resolution RGB color monitor, a minimum of 640 x 350 pixel resolution, and the capability to display a minimum of 16 colors. The Zenith ZVM-1390 (analog input) EGA color monitor is the current standard subject monitor. The NEC Multisync family of monitors meet these specifications and are suitable for use with the UTC-PAB system. Alternatives to these monitors are available and acceptable as long as they meet the above specifications.[2]

The original version of UTC-PAB was written before the EGA standard had been developed. The Sigma Designs Color 400-SH graphics board and the Princeton Graphic System Model SR-12 RGB color monitor (Fig. 2) were chosen to provide EGA-like (640 x 400) resolution. The Princeton SR-12 monitor requires the Sigma Designs Model Color 400-SH Graphics board; it will not function with any other graphics board. Although the Sigma/Princeton combination is still supported, the Princeton SR-12 monitor is no longer in production and is now in short supply. The Sigma board is still available and supported, and will work with most multisync monitors.

MULTI-EVENT TIMER, WORKSTATION INTERFACE, AND VOICE SYNTHESIZERS[3]

Two hardware configurations are currently available for these functions. In one configuration, the Tecmar Labmaster board combines the multi-event timer and the workstation interface, and a separate component, the Votrax Synthesizer, provides speech synthesis capabilities. In the alternative configuration, the Systems Research Laboratory SRL-Labpac combines all three functions on one board.

Tecmar Labmaster and Votrax Configuration

The standard-option Tecmar Labmaster board provides timing functions plus analog and digital interfacing to the subject response panel. Minimal requirements/specifications for this unit are as follows:

1. 5 independent 16-bit timer/counters with 1 MHz crystal clock. (Used for timing stimulus durations, interevent intervals, and reaction times.)

2. 24 digital input/output (I/O) lines, programmable as three 8-bit ports. (Used for interfacing to an external subject response apparatus.)

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[2] The Zenith Z-439 board, previously shipped with the Z-248, supports only TTL monitors, such as the Zenith ZVM-1380. The Zenith Z-449 video board supports both analog and TTL monitors. The NEC Multisync monitors can be switched between analog and TTL input, and will function with any of the video boards listed.

[3] Presently, only two of the 25 UTC-PAB tests require a speech synthesizer: the Auditory-Sternberg Memory Task and the Dichotic Listening Task. Hence, laboratories that do not plan on using these tests will not require speech synthesizers.

3. 16-channel (single-ended)/8-channel (differential) analog to digital converter with 12-bit resolution, 30KHz conversion rate, input ranges from 0 to 10 V, and selectable jumper ranges of ±10 V. (Used for analog joystick tracking tasks.)

The Votrax Personal Speech Systems Text-to-Speech Synthesizer[4] meets the standard requirements for synthesizers that produce clear recognizable speech and operate via the RS-232C format. Two units are required for each workstation. A cable, part number V200-3TRS, is also required for each synthesizer ordered.

SRL Labpac Multifunction Board Configuration

The Systems Research Laboratory (SRL) PC-Labpac Multifunction Board, designed specifically for the UTC-PAB, combines the Multi-event Timer, Workstation Interface, and Voice Synthesis[5] functions into a single board.

SUBJECT RESPONSE PANEL[6]

The Stimulus Equipment Company's Mini-Modulus III is a standardized subject response panel that has been produced specifically for the UTC-PAB system. It is a modular "plug-in" style unit that can contain three subject-response apparatuses simultaneously (Fig. 3). In addition, it has a stereo jack for headphones or external speakers and two BNC jacks that allow the generation of TTL compatible trigger-out signals. Three response modules are required to run all 25 UTC-PAB tests. These include a tapping key, a 180-deg switching joystick, and a numeric keypad. In addition, the system includes software-driven utilities and interfaces with the microcomputer via an RS-232C port. The Mini-Modulus III comes in two versions. The version for use with the Tecmar Labmaster board (Part #SE-002) includes a power box, while the version for use with the SRL Labpac board (Part #SE-001) does not.

NETWORKING CAPABILITY

A Local Area Network (LAN), although not required, is recommended when running multiple workstations. A LAN allows the user to run a single copy of the test software from the network system. This significantly simplifies test modification and assures that all subjects are using the same version of a test. A network also provides better security, as subjects can be prevented from accidentally tampering with tests or data files located on the network.

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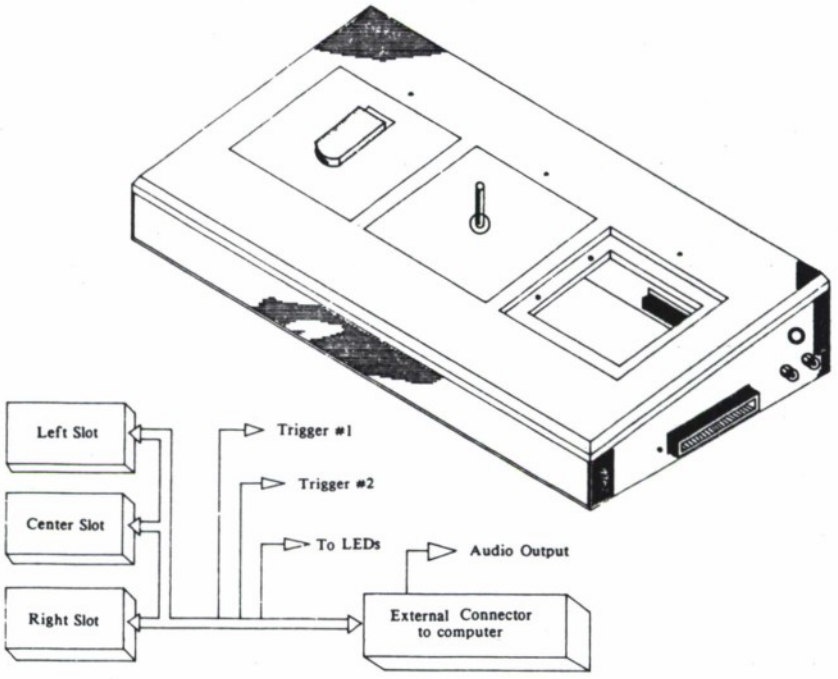
[4] Presently, the UTC-PAB configuration system supports only the Votrax Speech Synthesizer.

[5] Although the UTC-PAB does not presently support the Labpac's Digitalker synthesizer, the JWGD3 MILPERF has developed "stand-alone" software for the Auditory Sternberg Memory and Dichotic Listening tests.

[6] This system was designed and endorsed by the JWGD3 MILPERF Level II Task Area Group to address potential problems associated with nonstandardization of IBM-PC compatible keyboards. A keyboard version of the UTC-PAB has been developed, hence, use of the response panel is not mandatory.

SUBJECT RESPONSE PANEL



Functional Block Diagram

Figure 3. Schematic illustration of the subject response panel. The Mini-Modulus III is recommended for standardization among collaborating laboratories, however, it is not essential for running the UTC-PAB software.

Local Area Networks that have been used and proven reliable are Nestar Plan 4000 and Nestar Plan 5000 from DSC Nestar Systems. These units are no longer available, but the Planstar 70 (from DSC Nestar Systems) provides the same capability. This system will allow networking of up to 255 test stations while maintaining timing accuracy, the sharing of common data files, and expansion of the system at a modest cost per new station. The Planstar 70 includes a 150MB hard disk, Arcnet Token Ring support, NETBIOS capabilities, and integrated tape backup. It is compatible with the Nestar Plan 4000 and Plan 5000 models. Required components of the Planstar 70 are listed below:

	Item Description	Item Number
1.	Nestar Planstar 70 (file server with 150MB hard disk)	C6070
2.	16 Port Hub (1 per 15 workstations)	C4721
3.	IBM-PC/AT Network Interface Card (1 per test station)	C4710
4.	Cables and BNC Connectors (as needed)	N/A

RECOMMENDED OPTIONAL EQUIPMENT

Although not absolutely required, an uninterruptible power supply (UPS) is highly recommended for use with the LAN File Server and the individual subject workstations. This is particularly desirable if power outages, lightning, or brownouts are common in your area.[7] A UPS provides power to continue functioning in the event of an outage, and more importantly, protects equipment from a possible "head crash" following an outage. A 1KVA UPS system is sufficient protection for the LAN File Server, while a 500VA UPS can protect a single workstation. We recommend a ferroresonant inverter type of UPS because it provides constant on-line protection with no lag between the time the outside power shuts off, and the UPS system picks up the load.

RETAIL EQUIPMENT SOURCES

1. The Zenith Z-248 microcomputer is available from Zenith Data Systems, 8521 Leesburg Pike #700, Vienna, VA 22180, (800) 582-0030 or (703) 821-0140. Comparable equipment, as well as the Z-248, is also available from Government Technology Services, Inc., 14130-B Sullyfield Circle, Chantilly, VA 22021-1615, (703) 631-1177.

2. The NEC Multisync II monitor (as well as the Princeton monitor and the Zenith monitor) is available from Government Technology Services, Inc., 14130-B Sullyfield Circle, Chantilly, VA 22021-1615, (703) 631-1177.

3. The Princeton monitor is available from Princeton Graphic Systems, 601 Ewing St., Bldg. A, Princeton, NJ 08540, (800) 221-1490. Alternative retailers include: Computer Connection, 17121 S. Central Ave., Unit L, Carson, CA 90746, (800) 732-0304 and Progressive Micro Distributors, 7000 Peachtree Industrial Blvd., Norcross, GA 30071, (800) 446-7995 (for orders) and (404) 446-7995 (for information).

4. The Sigma graphics board is available from Sigma Designs, 46501 Landing Parkway, Fremont, CA 94538, (415) 770-0100.

5. The Tecmar Labmaster Board may be purchased from Scientific Solutions, Inc., 6225 Cochran Rd., Solon (Cleveland), OH 44139-3377, (216) 349-0600; Government Technology Services, Inc., 14130-B Sullyfield Circle, Chantilly, VA 22021-1615, (703) 631-1177; or through the national chain of Hallmark Electronics.

6. The Votrax Personal Speech Systems Text-to-Speech Synthesizer may be purchased from Votrax, Inc., 1394 Rankin, Troy, MI 48083, (313) 588-2050.

7. The Systems Research Laboratory (SRL) PC-Labpac Multifunction Board may be purchased from Systems Research Laboratory, 2800 Indian Ripple Rd., Dayton, OH 45440, (513) 426-6000, POC: Jim Moore.

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[7] Power outages of less than 1 s are sufficient to cause "head crashes," resulting in loss of data or possible destruction of the hard disk.

8. The Mini-Modulus III is available from Stimulus Equipment Company, Inc., 1421 Pissarro Circle, Virginia Beach, VA 23456, (804) 474-2597. Schematics of the Mini-Modulus III (Tecmar version) are also available from Stimulus Equipment Company.

9. The Nestar POC for the JWGD3 is Mr. Jim Bullard (703) 524-4044, DSC Nestar Systems, Inc., 1501 Wilson Blvd., Suite 403, Rosslyn, VA 22209.

10. Ferroresonant inverter type UPS systems can be purchased from Best Power Systems, P.O. Box 280, Nedecah, WI 54646, Attention: Mary Terese Paul, 1-800-356-5794 or (608) 565-7200, or from Abacus Controls, Inc., 80 Readington Rd, Somerville, NJ 08876, (201) 526-6010.

THE OPERATING (SOFTWARE) SYSTEM

GENERAL INFORMATION

The software environment for the UTC-PAB is divided in two major components: 1) a Configuration System to create individual tests and test menus; and 2) a Run Time System for actual subject testing and data collection (Fig. 4).

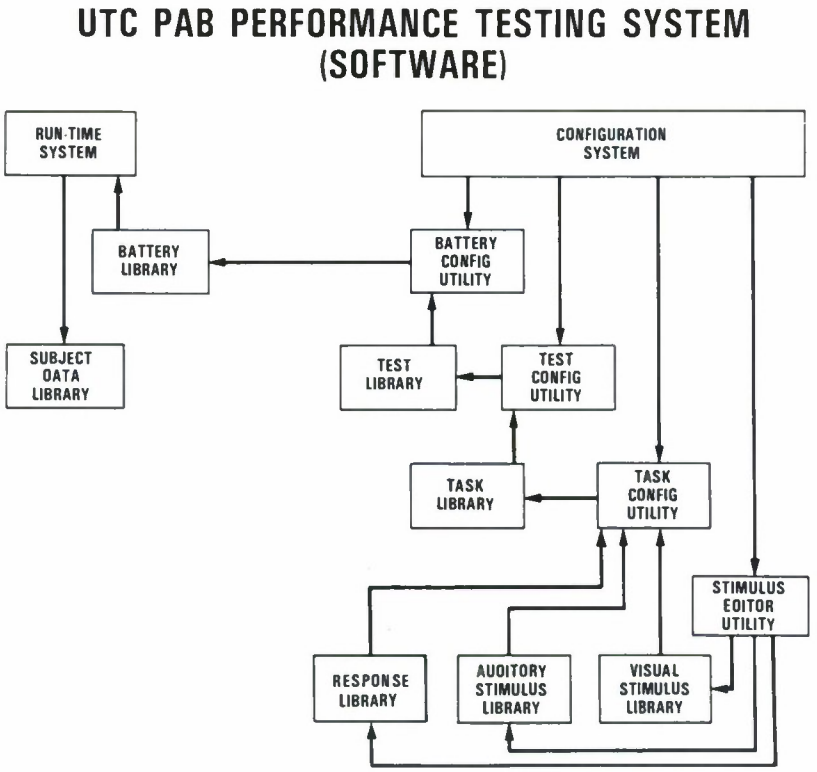

Figure 4. Schematic representation of the UTC-PAB operating system. The Configuration System (depicted on the right) is used to construct individual tests and batteries. These are then administered via the Run Time System, which is depicted on the left.

Software is written primarily in the C language, with assembly language used for those portions where C is not adequate for performance considerations. As with other components of the PAS, a primary goal is standardization while utilizing a software environment that combines the ease of use of a high-level, structured language with the power and efficiency of assembly language. Related considerations are ease of code maintenance, portability between systems, and compatibility with future systems. Specifically, the Lattice C compiler and Microsoft Macro Assembler are being used for software development. End users will not need C or assembly language programming capability.

The primary language reference and working standards for this effort are those found in:

1. Kernighan, B. and Ritchie, D., The C Programming Language, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1978.

2. Harbison, S.P. and Steele, G.L., Jr., A C Reference Manual, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1984.

3. Plum, T., C Programming Guidelines, Prentice-Hall Inc., Englewood Cliffs, NJ, 1984.

THE CONFIGURATION SYSTEM

The Configuration System is an interactive, integrated, menu-driven system that permits the creation of a UTC-PAB test battery by a life-science professional who need not be a computer programmer. Each phase of the configuration process has context-sensitive help screens available as a window display option. The structure of the system is hierarchical and includes the following elements:

1. Battery Library. A collection of batteries that provides the current selections for the Run Time System. For our purposes, a battery is defined as one or more tests from the UTC-PAB.

2. Battery Configuration Utility. A subprogram that permits the author to combine elements from the Test Library to create a specific battery that can be executed by the Run Time System.

3. Test Library. A structured collection of previously created tests. The tests are stored in a compressed library format that can be accessed and expanded by the Battery Configuration Utility. A directory listing of the Test Library is available from the Battery Configuration Utility.

4. Test Configuration Utility. A subprogram that allows the author to combine elements from the Task Library to create a test.

5. Task Library. A collection of previously configured tasks. Tasks are composed of intervals and delays that constitute the basic unit for presenting information (visual and auditory stimuli) and obtaining responses. Individual intervals are defined by their type of stimuli (visual or auditory), the sequence for presentation of stimuli, specified delays between stimulus presentation, the range of allowable responses, specification of correct and incorrect responses, and the sequence of responses.

6. Task Configuration Utility. A subprogram that allows the author to combine elements from visual stimuli, auditory stimuli, and response-definition libraries to create a task.

7. The Stimulus/Response Editors. A construction utility for creating libraries of visual stimuli, auditory stimuli, and response definitions as described below.

8. Response-Definition Library. A collection of previously constructed response definitions. Responses may be specified as single keystroke or release functions, or they may be defined as "key-string" responses. Presently, the computer keyboard is the only input device, however, a version that will allow use of the Modulus III apparatus is under development and is scheduled for completion by the third quarter of FY89.

9. Visual Stimulus Library. A collection of previously prepared visual stimulus displays. This system will be operated initially from the keyboard. Visual stimuli may be constructed using either a stimulus editor or commercially available graphics programs. If the latter option is selected, screen displays such as "cut files" may be incorporated in the Stimulus Library through the use of an "import" utility. The import option is controlled from the Run Time System.

10. Auditory Stimulus Library. A collection of previously prepared auditory stimulus materials that will include the following:

    a. tones of specified frequency and duration
    b. phonemes
    c. syllables
    d. words
    e. short sentences.

The Configuration System is accessed through a menu-driven shell that permits the user to activate any of the utilities to query and maintain the libraries. Additionally, a complete command facility allows the familiar user to utilize the system quickly and directly. Help for the operator is context sensitive and available in all programs of the Configuration and Run Time Systems. Error handling procedures present "plain English" messages indicating the cause of the error and the action necessary for recovery.

THE RUN TIME SYSTEM

The Run Time System provides a means for the operator to enter test and subject information, select test batteries to be administered, start the running of selected batteries, and terminate the session. The Run Time System includes the following:

1. Session Initialization. The Run Time System boots up directly to the operator's control menu with the selection cursor blinking on the "Enter Subject Information" choice. If the subject header information has been entered previously, other options may be exercised, and the same header information will be appended to any files or reports that are generated. A repetition count will be entered into repeated headers. Other options available are "Select a Battery," "Start the Session," "Toggle Help Mode," and "Quit." "Select a Battery" presents an index of the batteries present in the Battery Library. If "Start the Session" is selected, the subject header and the name of the selected battery are displayed. "Quit" closes all open files and provides the operator with the options of putting in a system disk and rebooting the system (for use as a normal PC),

or quitting for the day. "Quit" provides the only legitimate method of exiting the Run Time System; however, pressing the ESC key returns the system to the immediately preceding operation.

2. Session Termination Function. A session is a single run through a battery. A session is complete when the last task of the last test has been completed. At that point, all open files are closed, and the system returns to the main menu.

3. Error Recovery Function. All error messages are in "plain English" and indicate the nature of the error and what the operator must do to recover from the error.

4. Battery Library. As described in the previous section with the exception that this library is resident on the disk with the Run Time System. The Run Time System also enables an operator to temporarily suspend any test by activating a special keyboard input. This allows the operator to attend to special problems (e.g., equipment or test subjects) and then resume testing from the point where the test was suspended. Another option is available to immediately close the data files and return to the main menu.

In a floppy-disk based system, the Configuration System resides on one set of disks and the Run Time System on another set to provide maximum space for the creation of the Battery Library. Transfer of the Battery Library to an appropriate Run Time System disk is prompted for and checked by the Configuration System Shell. In a hard disk system, the two systems can reside in separate directories or volumes.

SUBJECT DATA FILES

The subject data files describe the events and durations that occurred during the operation of a test. All data files have a header that identifies the file, the test, and the battery from which it was generated, and subject and time/date information. Data and headers are stored in ASCII format so they can be read without requiring decoding or unpacking.

In a dual floppy system, the data files reside on a separate disk from the Run Time System. Because the size of a data file associated with a given battery is known, the available space on the data disk will be checked before opening a new Data Library. If insufficient space remains on the data disk, the operator is prompted for another disk on which to store the data.

BETA TESTING

One of the final stages in this project involves testing the operating system through user applications (i.e., beta testing). This is being accomplished through voluntary and assigned efforts among the JWGD3 MILPERF associated laboratories. Any "bugs" and deficiencies according to the specifications detailed in the Statement and Scope of Work will be corrected by the contractor. Beta testing is ongoing, and a user version is scheduled for distribution mid-FY89. Laboratory representatives who are interested in

participating in the UTC-PAB program may write to the following address and request further information:

Commander
Walter Reed Army Institute of Research
Attn: WRAIR-SGRD-UWI/LTC Sessions
Washington, DC 20307-5100.

Other Related Publications

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